Name _____Period _____

# Chemical Formulas

| Your Tasks (Mark these off as you go) |
|---|
| ☐ Assign group roles |
| ☐ Review molar mass of compounds |
| ☐ Review mass-mole-molecule conversions |
| ☐ Determine the formula for a compound |
| ☐ Write your own conclusion |
| ☐ Receive credit for this lab |

## ❑ Assign group roles

Before you continue, record your group number, then collaborate with your group and assign each person a role. Each role and a description is provided below.

| | |
|---|---|
| **Project manager (PM)** | Leads the team discussion and keeps the team on task and on schedule. Considers how the team is working and ensures all voices are heard. Makes sure the final lab is submitted. |
| **Recorder (R)** | Ensures that all members have correct answers. Presents answers (or questions) to the class, instructor, or other teams. |

| **Group Number:** | |
|---|---|
| **Name** | **Role** |
| | |
| | |

## ❑ Review molar mass of compounds

The molar mass of a compound is the mass of 1 mole of the compound. It can be calculated by summing the atomic masses that make up the compound. For example, $H_2O$ contains 2 hydrogens, each with a mass of 1.0 g and 1 oxygen, which has a mass of 16.0 g. The mass of 1 mole of $H_2O$ is therefore,

1 mole = 2(1.0 g) + 16.0g = 18 g

| Calculate the mass of 1 mole of each of the following |
|---|
| $CuSO_4$ |
| $Al(NO_3)_3$ |

| How much in moles is each of the following? |
|---|
| 122.55 g of $KClO_3$ |
| 98.079 g of $H_2SO_4$ |

Recall that 1 mole is also equivalent to $6.022 \times 10^{23}$ things. So, if we wanted to know the mass of $6.022 \times 10^{23}$ molecules of oxygen we can calculated the same way we did for 1 mole,

1 mole = $6.022 \times 10^{23}$ molecules = 2(1.0 g) + 16.0g = 18 g

| Calculate the mass of $6.022 \times 10^{23}$ of each of the following |
|---|
| $Al_2O_3$ |
| $(NH_4)_2SO_4$ |

| How many molecules are in each of the following? |
|---|
| 17 g of $NH_3$ |
| 28 g of CO |

## ❑ Review mass-mole-molecule conversions

Knowledge of the mass of the compound enables for the calculation of the number of moles, mass, or individual molecules in a given sample.

1 mole = $6.022 \times 10^{23}$ atoms = mass of compound (g)

Just as before, when using this relationship, it is important to show your work. Using the units to guide you through the problem-solving process will help ensure you arrive at the correct result. Below is an example of how this can be done.

Example

Determine the number of moles in 12.0 g of $H_2O$.

To set up this problem we first identify the given which is 12.0 g of $H_2O$ and the unknown which is moles.

| given | conversion | asked to find (unknown) |
|---|---|---|
| **12.0 g $H_2O$** | | **moles oxygen** |
| | | |

Next, we identify the conversion factor.

1 mole = mass of $H_2O$ (g)

On the periodic table we see that the mass of oxygen is 16.0 g and the mass of hydrogen is 1.0 g. So the mass of 1 mole of $H_2O$ is,

1 mole = 2(1.0 g) + 16.0g = 18.0 g

Or,

1 mole = 18.0 g

Next, we arrange the conversion factor such that what we are asked to find appears on top and what we are given appears on the bottom.

| given | conversion | asked to find (unknown) |
|---|---|---|
| 12.0 g $H_2O$ | **1 mole $H_2O$** | moles $H_2O$ |
| units must match → | **18.0 g $H_2O$** | |

Now that we have set up our problem, we can solve for what we are asked to find. To do this, we multiply the quantities on top, then divide by the quantities on the bottom. The result is 0.50 moles oxygen. Notice, that the grams cancel, and we end with moles as our final unit.

| given | conversion | asked to find (unknown) |
|---|---|---|
| 12.0 g $H_2O$ × | 1 mole $H_2O$ | **0.67 moles oxygen** |
| | 18.0 g $H_2O$ ÷ | |

g cancel

**Skill 10.03 Exercise 1**

How much in moles is 10.0 g of water ($H_2O$)?

| **Conversion factor** | | |
|---|---|---|
| | | |
| **Given** | **Conversion** | **Asked to find (unknown)** |
| | | |
| | | |

How much in grams is 1.25 moles of carbon monoxide (CO)?

| **Conversion factor** | | |
|---|---|---|
| | | |
| **Given** | **Conversion** | **Asked to find (unknown)** |
| | | |
| | | |

How much in grams is $6.022 \times 10^{22}$ molecules of nitrogen dioxide ($NO_2$)?

| **Conversion factor** | | |
|---|---|---|
| | | |
| **Given** | **Conversion** | **Asked to find (unknown)** |
| | | |
| | | |

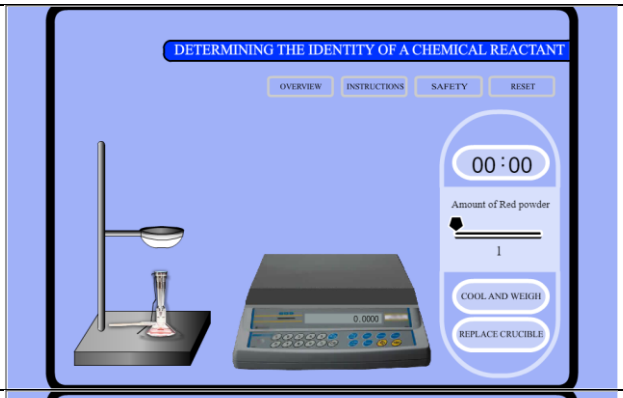
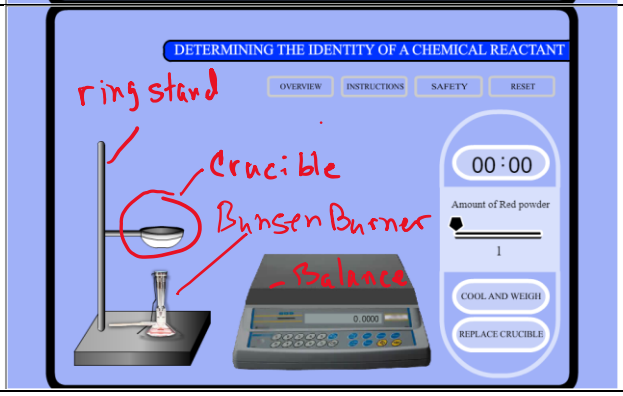
How many molecules are the in 4.25 g of hydrogen peroxide ($H_2O_2$)?

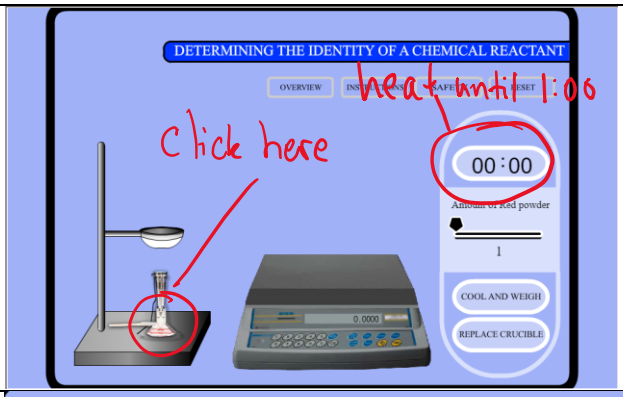
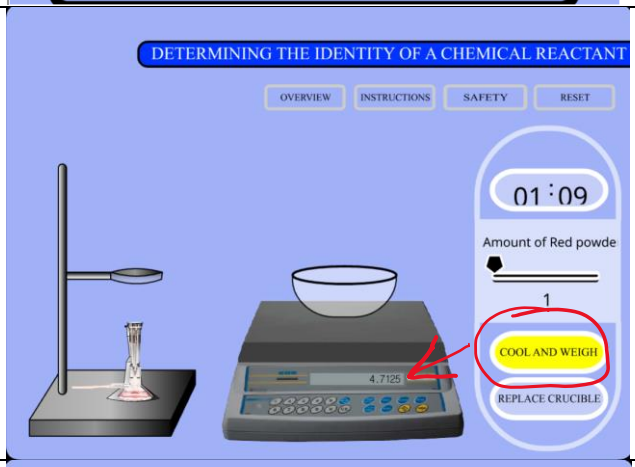
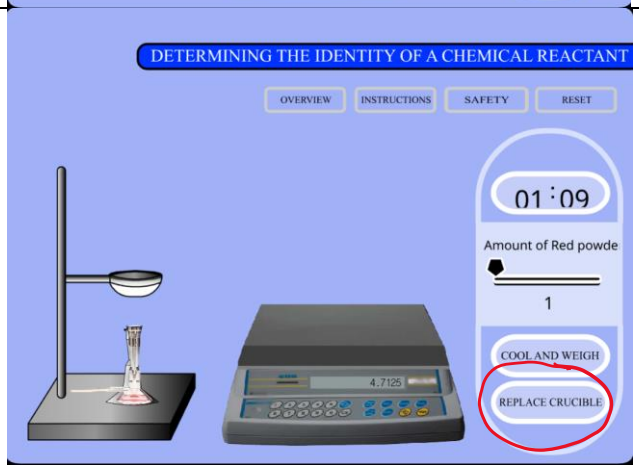
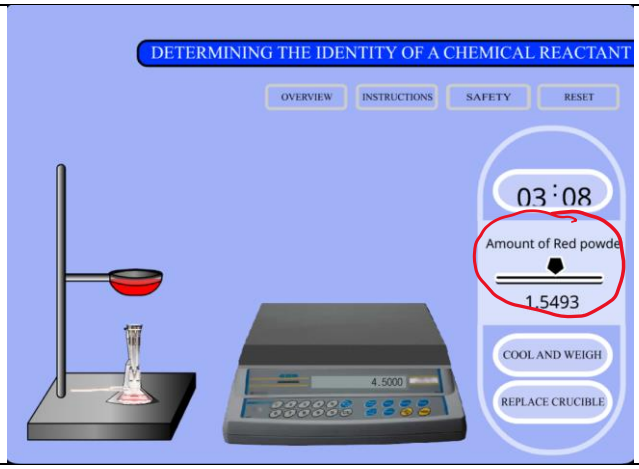
| **Conversion factor** | | |
|---|---|---|
| | | |
| **Given** | **Conversion** | **Asked to find (unknown)** |
| | | |
| | | |

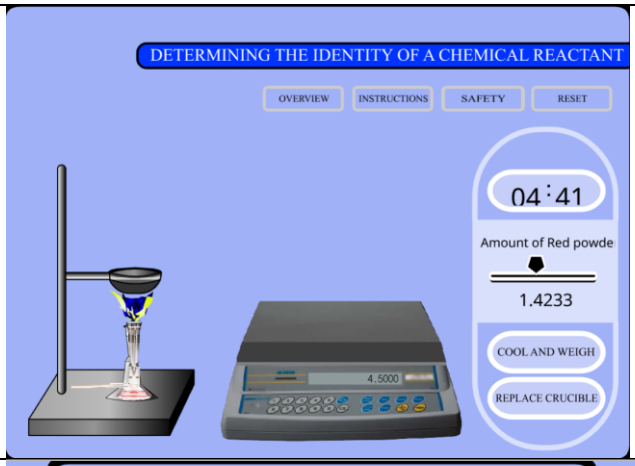
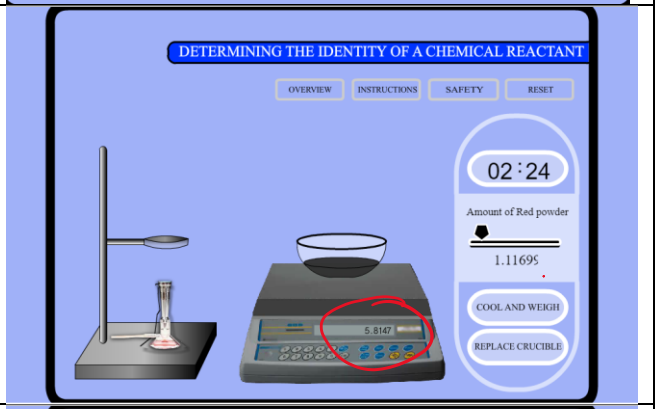
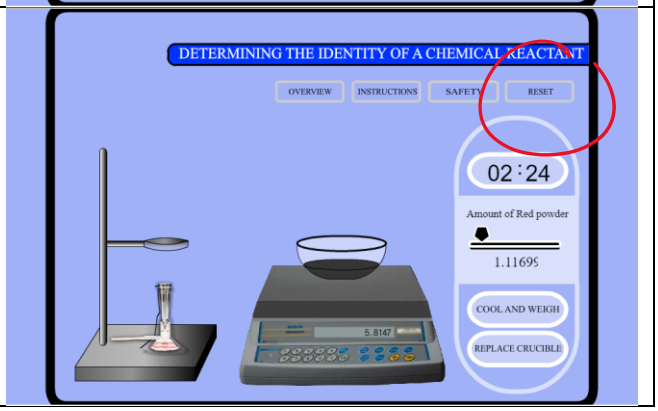
## ❑ Determine the formula for a compound

For the is part of the lab we will be using the virtual simulator located at the link below. This simulator using the Flash plugin and will require you to enable it.

https://hpluska.github.io/Chemistry/labs/ChemicalFormulas/Index.html

| | |
|---|---|
| Locate the simulator for Part 1.<br><br>In this portion of the lab, you will determine the formula for a compound containing copper and oxygen. If we represent the formula as $Cu_xO_y$ the goal is to determine the values of the subscripts x and y. |  |
| Before you begin check out the screen shot to the right to learn the names of the equipment we will be using. |  |

| | |
|---|---|
| Before we get started, we need to make sure the crucible is completely dry. To do this, we will heat it with the Bunsen burner.<br><br>Click on the base of the Bunsen burner to turn on the flame. Click on the base of the Bunsen burner again, to turn it off.<br><br>Heat until the timer reads about 1:00 |  |
| To get the weight of the crucible, click the "COOL AND WEIGH" button.<br><br>Record the mass of the empty crucible in the data table below as "Mass after first heating". |  |
| Click on the "REPLACE CRUCIBLE" button to place the crucible back on the ring stand.<br><br>Click on the base of the Bunsen burner to turn on the flame.<br><br>Heat until the timer reads about 2:00<br><br>Click the "COOL AND WEIGH" button.<br><br>Record the mass of the empty crucible in the data table below as "Mass after second heating".<br><br>Repeat the above until you have two mass measurements that are the same. |  |
| With the crucible on the ring stand and the burner turned off, move the slider to add between 1 and 2 grams of red copper powder to the crucible.<br><br>Record the weight of the red powder in the data table below. |  |

| | |
|---|---|
| Click on the Bunsen Burner to heat the contents in the crucible until they turn black. |  |
| Click the “COOL AND WEIGH” button and record the final weight. |  |
| Click the reset button. Re-run the simulator for a total of two trials. |  |

**Data Table**

| **Trial 1** | |
|---|---|
| Empty Crucible | |
| Mass after first heating | |
| Mass after second heating | |
| Mass after third heating | |
| Mass of red copper powder | |
| Mass of crucible and black copper oxide powder | |
| **Trial 2** | |
| Empty Crucible | |
| Mass after first heating | |
| Mass after second heating | |
| Mass after third heating | |
| Mass of red copper powder | |
| Mass of crucible and black copper oxide powder | |

Analysis

In this experiment, copper (Cu) reacted with oxygen (O) to create a compound containing copper oxide ($Cu_xO_y$). This process can be represented with the following reaction. Notice we use x and y to represent the amounts of copper and oxygen in our final formula, because we do not know what they are. In the section below, you will figure it out!

$Cu + O_2 \rightarrow Cu_xO_y$

| Refer to the data you collected above. What is the mass of the crucible? | |
|---|---|
| **Trial 1 mass crucible** | **Trial 2 mass crucible** |
| | |
| How do you know which mass to use? | |

| Refer to the data you collected above. Calculate the mass of the black copper oxide powder for each trial. **Show your work**. | |
|---|---|
| **Trial 1 mass copper oxide** | **Trial 2 mass oxide** |
| | |

Refer to the data you collected above. Calculate the mass of oxygen that reacted for each trial. Then convert the mass of oxygen to moles. **Show your work in the tables provided**.

| **Trial 1 mass of oxygen** | | | **Trial 2 mass of oxygen** | | |
|---|---|---|---|---|---|
| | | | | | |
| **Trial 1 moles of oxygen** | | | **Trial 2 moles of oxygen** | | |
| **1 mole O = 15.999 g** | | | **1 mole O = 15.999 g** | | |
| | **Conversion** | | | **Conversion** | |
| | | | | | |
| | | | | | |

Refer to the data you collected above. Calculate the moles of red copper powder that reacted. **Show your work in the tables provided**.

| **Trial 1 moles of copper** | | | **Trial 2 moles of copper** | | |
|---|---|---|---|---|---|
| **1 mole Cu = 63.546 g** | | | **1 mole Cu = 63.546 g** | | |
| | **Conversion** | | | **Conversion** | |
| | | | | | |
| | | | | | |

Recall that the reaction between copper and oxygen can be depicted as follows.

$Cu + O_2 \rightarrow Cu_xO_y$

Now that we know the moles of copper and the moles of oxygen, we can determine subscripts x and y.

Let x equal the moles of copper. And, let y equal the moles the oxygen. To figure out the subscripts, simply reduce the moles to their simplest ratio. For example, consider the following results,

0.01873 moles Cu and 0.01297 moles O

We can rewrite the formula for $Cu_xO_y$ by replacing x and y with amounts in moles of Cu and O.

$Cu_{0.01873}O_{0.01297}$

Now we reduce the subscripts by dividing each subscript by the smaller of the two values,

$Cu_{\frac{0.01873}{0.01297}} O_{\frac{0.01297}{0.01297}} \Rightarrow Cu_{1.44}O_1$

Notice, in the result, $Cu_{1.44}O$ still has a decimal as a subscript. While this isn't ideal, it is an experiment, and experiments sometimes produce unexpected results.

| Using the moles of Cu and O you calculated, determine the formula for $Cu_xO_y$ for each trial. | |
|---|---|
| **Trial 1** | **Trial 2** |
| | |

## ❑ Write your own conclusion

A conclusion is a concise summary of the lab. A conclusion should include the following elements (1) The purpose of the lab, (2) A summary of what you did to accomplish the purpose (3) A summary of your results (4) A summary of errors. For this lab we will only consider the first three parts.

In the space below, use complete sentences to summarize the purpose of this lab.

| |
|---|
| |

In the space below, use complete sentences to describe what you did to accomplish the purpose. You could say for example, "In this lab, we used a simulator to determine the formula for $Cu_xO_y$. We began by weighing a crucible to constant mass. We then… "

| |
|---|
| |

In the space below, use complete sentences to summarize your results. Also indicate whether or not results make sense and why. You could say for example, "For the first trail we obtained a formula of $Cu_{1.44}O$. For the second trail…". "The results from our first trial were not what we had expected, because… "

| |
|---|
| |

## ❑ Receive Credit for this lab

Each group member must complete and submit their own lab to receive credit